PULMONARY FUNCTION TESTS

SPIROMETRY

- Spirometry is a physiological test that measures how an individual inhales or exhales volumes of air as a function of time.

- Spirometry assesses the integrated mechanical function of the lung, chest wall, and respiratory muscles by measuring the total volume of air exhaled from a full lung (total lung capacity [TLC]) to maximal expiration (residual volume [RV]).

INDICATIONS FOR SPIROMETRY

- Diagnostic

To establish baseline lung function.

To evaluate symptoms like dyspnea, signs or abnormal laboratory tests

To detect or screen individuals at the risk of pulmonary diease

To measure the effect of disease on pulmonary function

To assess pre-operative risk

To assess prognosis

- Monitoring

To assess therapeutic intervention

To describe the course of diseases that affect lung function

To monitor people exposed to injurious agents and surveillance of occupation related lung disease.

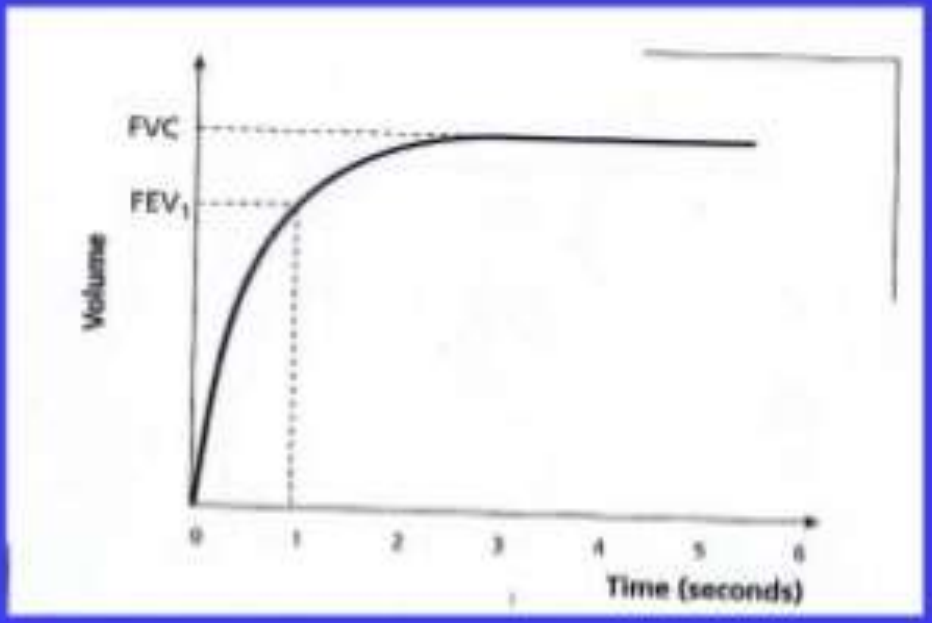
To monitor for adverse reactions to drugs with known pulmonary toxicity

To assess patients as part of a rehabilitation programme

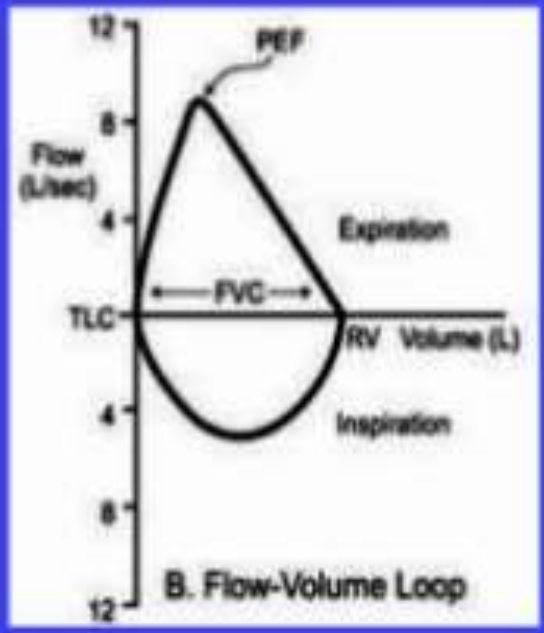
CONTRAINDICATIONS FOR SPIROMETRY

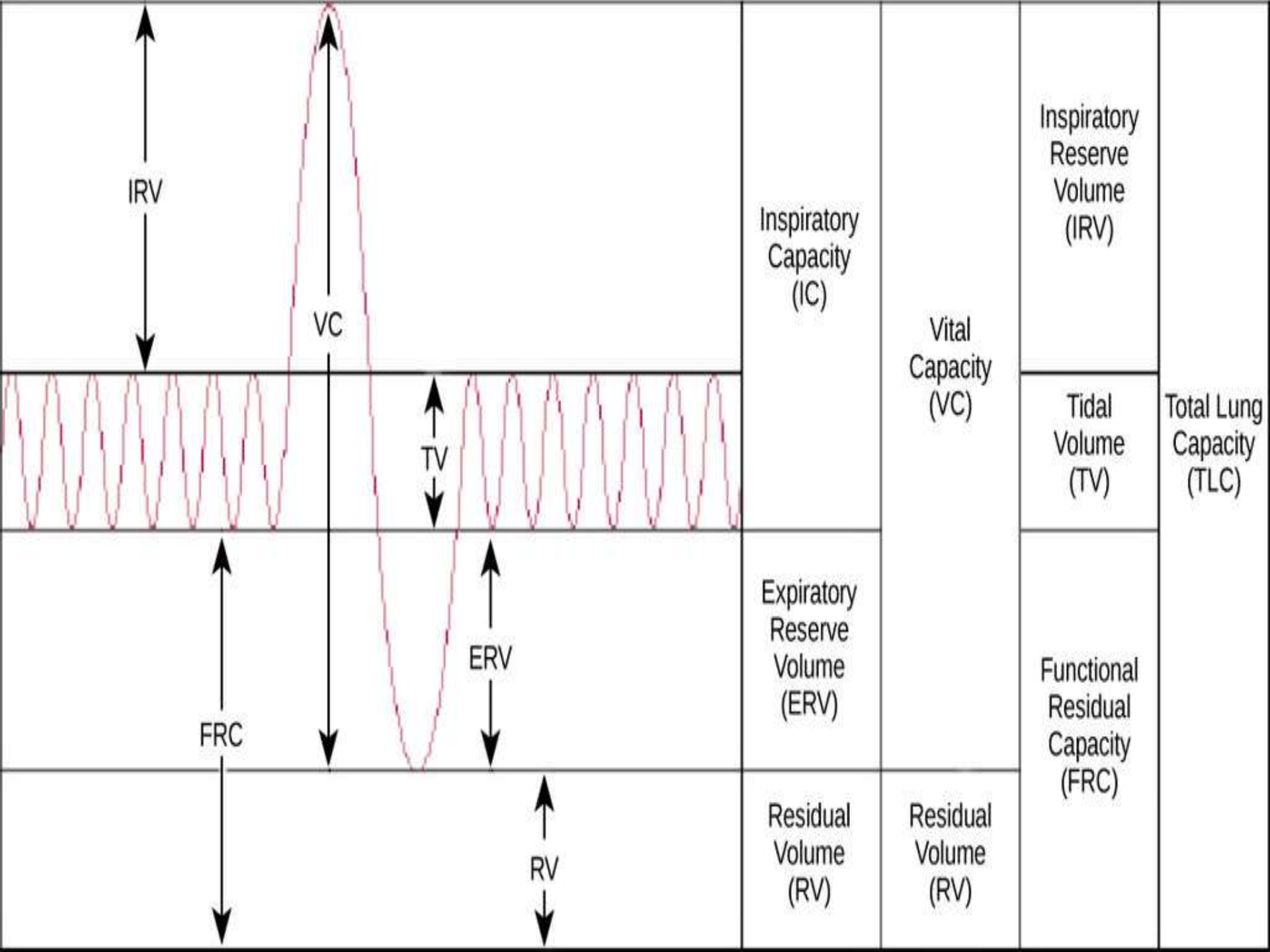
- Contraindications:
- Hemoptysis of unknown origin
- Pneumothorax
- Unstable angina pectoris
- Recent myocardial infarction
- Thoracic aneurysms, abdominal aneurysms, cerebral aneurysms
- Recent eye surgery (within 2 weeks due to increased intraocular pressure during forced expiration)
- Recent abdominal or thoracic surgical procedures
- Patients with a history of syncope associated with forced exhalation.
- Patients with active tuberculosis should not be tested.

1. Volume Time Graph



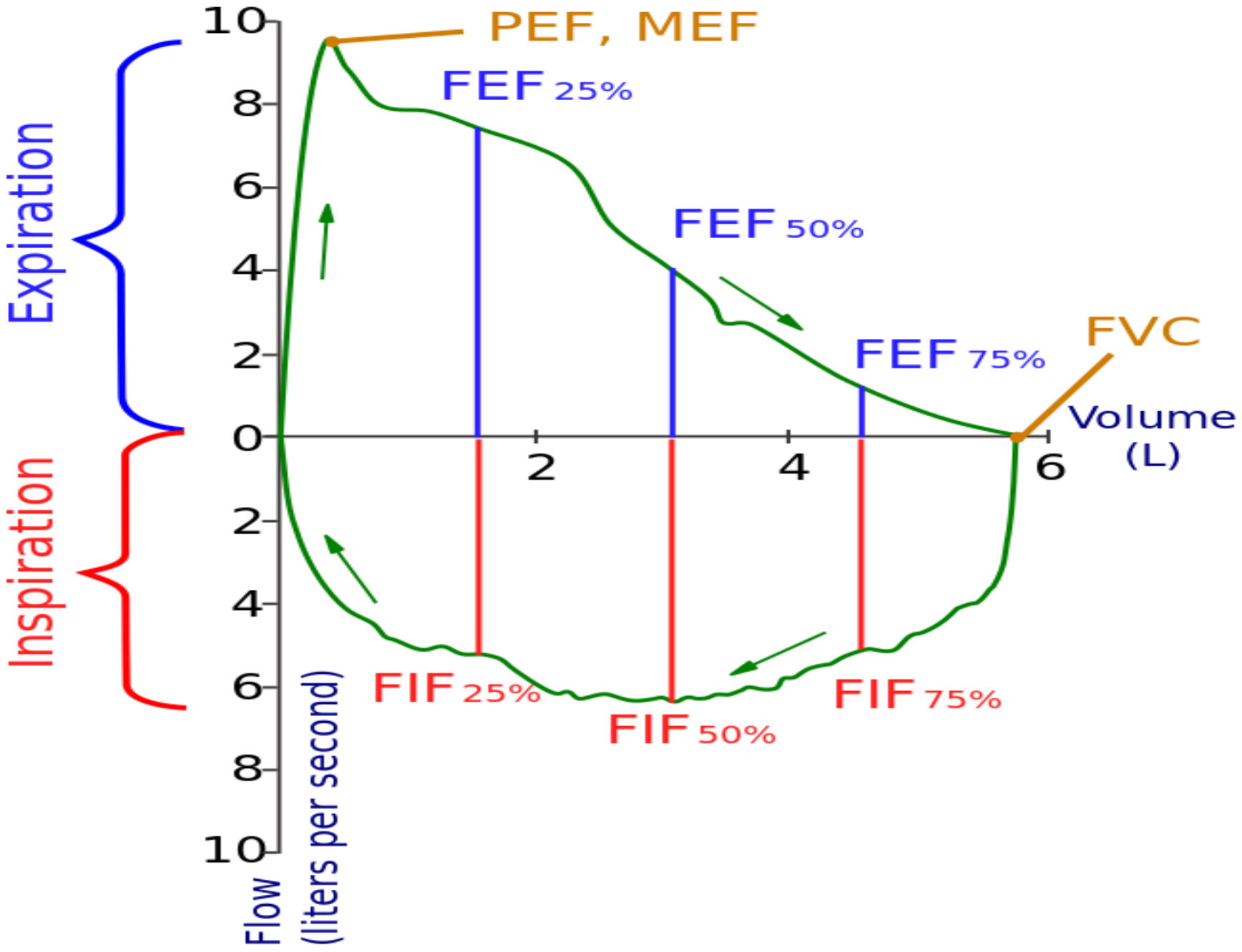
2. Flow-volume loops




IRV
VC
TV
FRC
ERV
RV
Inspiratory Capacity (IC)
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Vital Capacity (VC)
Residual Volume (RV)
Inspiratory Reserve Volume (IRV)
Tidal Volume (TV)
Functional Residual Capacity (FRC)
Total Lung Capacity (TLC)

- FORCED VITAL CAPACITY (FVC)– The volume of air that can be forcefully exhaled after a maximal inhalation.
- The majority of FVC can be exhaled in less than three seconds of exhalation in normal people, however it may be prolonged in people with obstructive lung diseases.
- Forced expiratory volume in 1 second (FEV1) – The volume of air exhaled in the first second of FVC.
- Normal subjects can exhale 75- 80% of their FVC in the first second, hence the FEV1/FVC ratio is an important determinant in assessing lung disease.

- **Forced expiratory flow (FEF)**
- Forced expiratory flow (FEF) is the flow of air coming out of the lung during the middle portion of a forced expiration. It can also be given as a mean of the flow during an interval, usually 25–75% (FEF25–75%).
- $FEF_{25–75\%}$—Forced expiratory flow over the middle one half of the FVC; the average flow from the point at which 25 percent of the FVC has been exhaled to the point at which 75 percent of the FVC has been exhaled.
- FEF25-75% is a more sensitive parameter than FEV1 in the detection of obstructive small airway disease.


PEF, MEF
FEF 25%
FEF 50%
FEF 75%
FVC
Expiration
Inspiration
10
8
6
4
2
0
2
4
6
2
4
6
8
10
Volume (L)
Flow (liters per second)
FIF 25%
FIF 50%
FIF 75%

- **Peak expiratory flow (PEF)** is the maximal flow achieved during the maximally forced expiration initiated at full inspiration, measured in liters per second.
- **Tidal volume (TV)** is the amount of air inhaled and exhaled normally at rest.
- **Maximum voluntary ventilation (MVV**) is a measure of the maximum amount of air that can be inhaled and exhaled within one minute. For the comfort of the patient this is done over a 15-second time period before being extrapolated to a value for one minute expressed as liters/minute. Average values for males and females are 140–180 and 80–120 liters per minute respectively.

HOW IS THE TEST PERFORMED

The patient is instructed to inhale as much as possible and then exhale rapidly and forcefully for as long as flow can be maintained. The patient should exhale for at least six seconds.

At the end of the forced exhalation, the patient should again inhale fully as rapidly as possible. The FVC should then be compared with that inhaled volume to verify that the forced expiratory manoeuvre did indeed start from full inflation.

The FVC and the FEV_1 should be repeatable to within 0.15 L upon repeat efforts unless the largest value for either parameter is less than 1 L. In this case, the expected repeatability is to within 0.1 L of the largest value.

TABLE 4 Procedures for recording forced vital capacity

Check the spirometer calibration

Explain the test

Prepare the subject

- Ask about smoking, recent illness, medication use, *etc.*
- Measure weight and height without shoes

Wash hands

Instruct and demonstrate the test to the subject, to include

- Correct posture with head slightly elevated
- Inhale rapidly and completely
- Position of the mouthpiece (open circuit)
- Exhale with maximal force

Perform manoeuvre (closed circuit method)

- Have subject assume the correct posture
- Attach nose clip, place mouthpiece in mouth and close lips around the mouthpiece
- Inhale completely and rapidly with a pause of <1 s at TLC
- Exhale maximally until no more air can be expelled while maintaining an upright posture
- Repeat instructions as necessary, coaching vigorously
- Repeat for a minimum of three manoeuvres; no more than eight are usually required
- Check test repeatability and perform more manoeuvres as necessary

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- Interpretation of spirometry results should begin with an assessment of test quality. Failure to meet performance standards can result in unreliable test results. The American Thoracic Society (ATS) defines acceptable spirometry as an expiratory effort that has the following characteristics:
- Starts from full inflation
- Shows minimal hesitation at the start of the forced expiration
- Shows an explosive start of the forced exhalation (time to peak flow no greater than 0.12 s)
- Shows no evidence of cough in the first second of forced exhalation

- Meets one of three criteria that define a valid end-of-test:

(1) smooth curvilinear rise of the volume-time tracing to a plateau of at least 1 second's duration

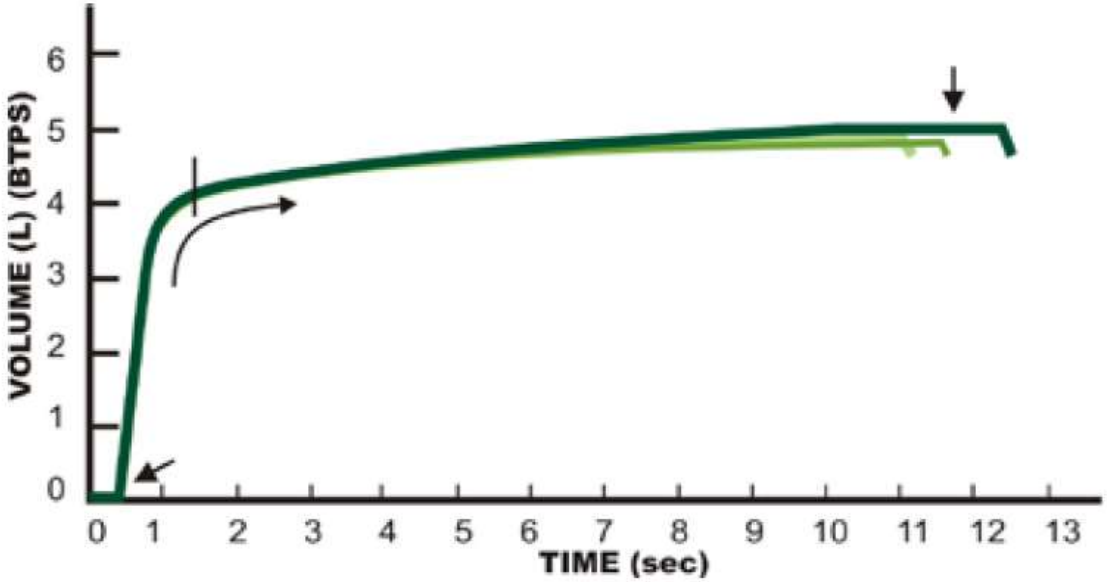
(2) If a test fails to exhibit an expiratory plateau, a forced expiratory time (FET) of 15 seconds

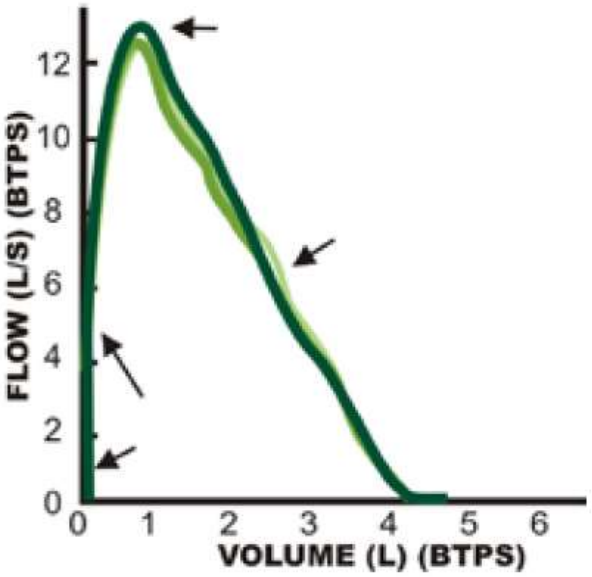
(3) when the patient cannot or should not continue forced exhalation for valid medical reason

Valid Normal Test

Trial	FVC (L)	FEV_1 (L)	PEF (L/sec)
1	4.81	4.09	12.1
2	4.74	4.07	12.0
3	**4.87**	**4.14**	**12.5**
Repeatability	0.06	0.05	

4.87-4.81 = 0.06 4.14-4.09 = 0.05





Height – Tall people have a higher lung volumes as compared to short people.

Age – Lung function declines with age.

Sex – Males and females have different sized lungs.

Race – White people generally have greater lung volume than dark people.

So on basis of the above differences, the Global Lung Initiative (GLI), a Task Force of the European Respiratory Society, published a report that provides normative values for males and females from aged 3-95 years across a wide range of ethnicities.

FVC

Interpretation of % Predicted:

80 -120% - Normal

70 – 79% - Mild

50 – 69% - Moderate

<50% - Severe

The severity of reductions in the FEV_1% can be characterized by the following scheme:

- **Mild - Greater than 70% of predicted**
- **Moderate - 60-69% of predicted**
- **Moderately severe - 50-59%**
- **Severe - 35-49% of predicted**
- **Very severe - Less than 35% of predicted**

OBSTRUCTIVE PATTERN VS RESTRICTIVE PATTERN

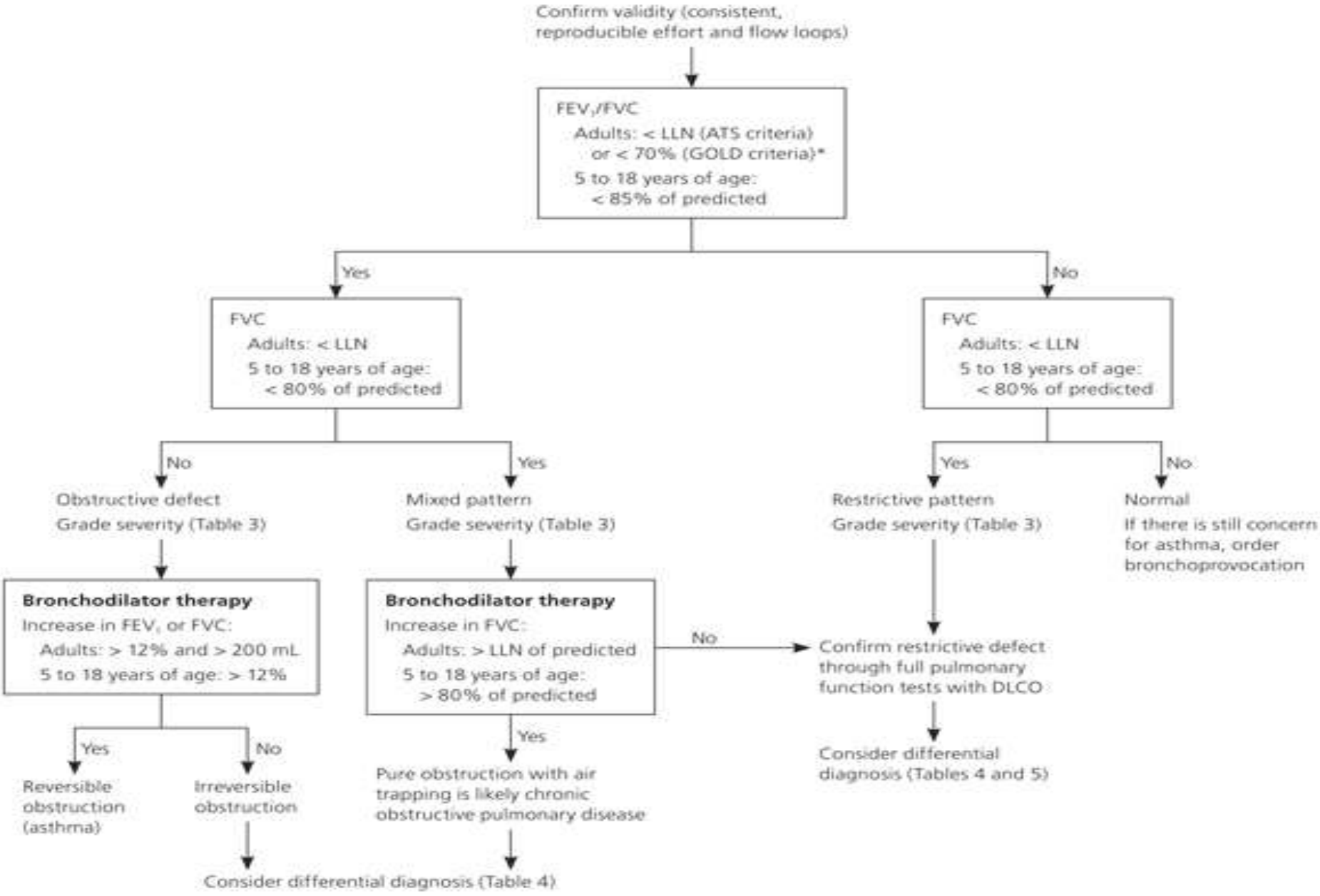
OBSTRUCTIVE

- TLC normal
- Normal or decreased FVC
- Decreased FEV1
- FEV1/FVC < 70% of predicted
- FEF 25-75% decreased

RESTRICTIVE

- TLC decreased
- FVC decreased
- Normal or decreased FEV1
- FEV1/FVC ratio> 70% of predicted
- FEF 25 – 75% normal or decreased.

- FEV1 used to follow severity in COPD.



NOTE: *A tool to calculate the LLN in adults up to 75 years of age is available at http://hankconsulting.com/RefCal.html.*

*—*The 70% criteria should be used only for patients 65 years and older who have respiratory symptoms and are at risk of chronic obstructive*

Obstructive lung diseases

- Asthma
- COPD
- Bronchietasis
- Emphysema
- Bronchiolitis
- Cystic fibrosis
- Upper airway obstruction

Restrictive lung diseases

- Intrinsic

1) Interstitial lung diseases (IPF, sarcoidosis)
2) Pneumoconiosis
3) Drug induced
4) Hypersensitivity pnuemonitis
5) ARDS

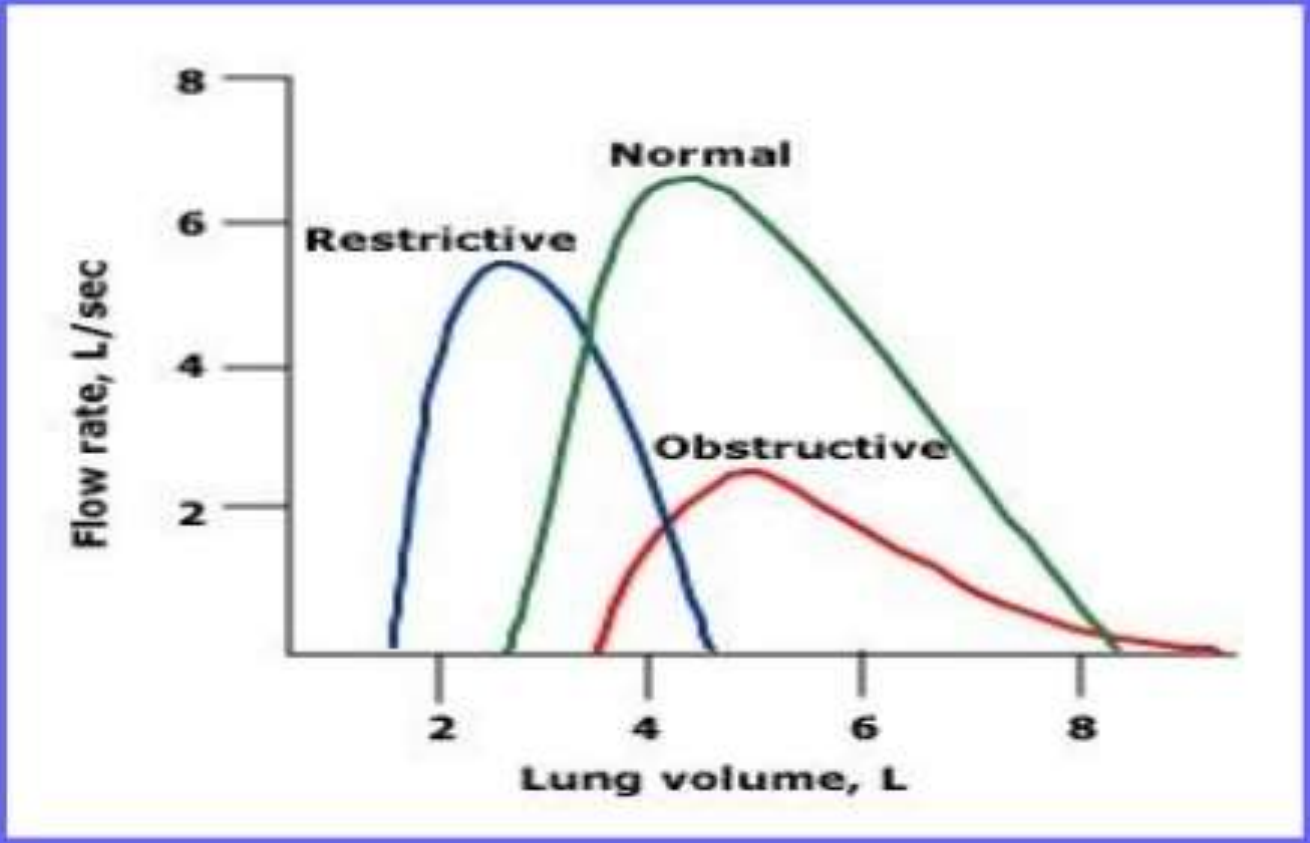
- Extrinsic

1) Pleural effusion
2) Pulmonary edema
3) Obesity
4) Ascitis

- Neuromuscular disorders

1) Diaphragmatic paralysis
2) Myasthenia Gravis
3) Poliomyelitis

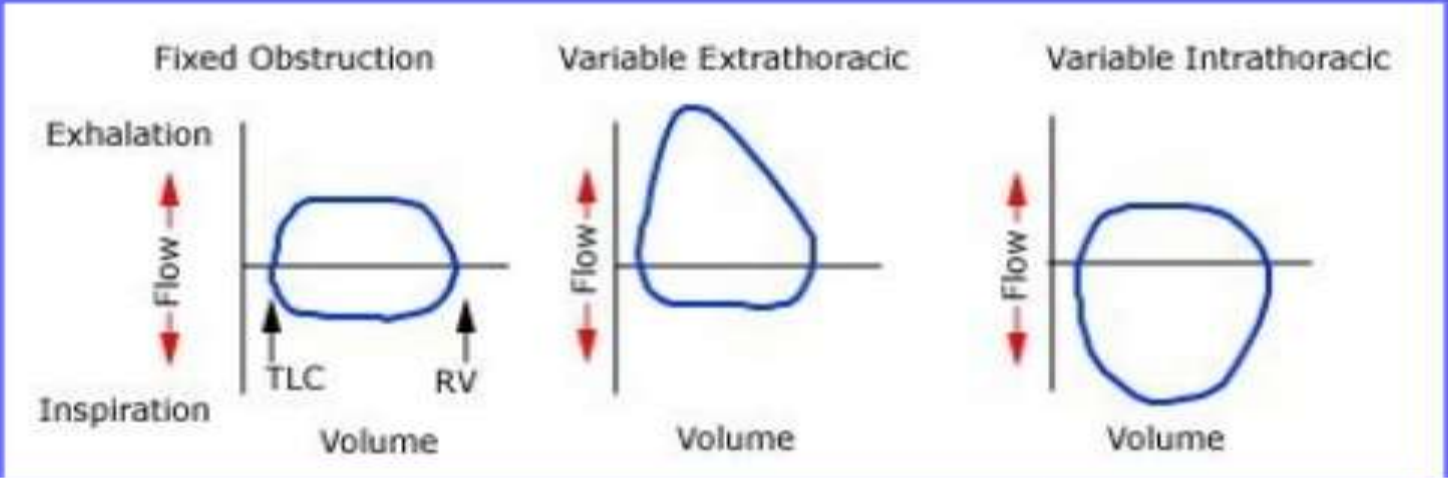
Spirometry Patterns



POST BRONCHODILATOR REVERSIBILITY

•Indicated if obstructive defect documented.
•Administer salbutamol in four separate doses of 100 mg through a spacer.
• Re-assess lung function after 15 min. If you want to assess the potential benefits of a different bronchodilator, use the same dose and the same route as used in clinical practice. The wait time may be increased for some bronchodilators.
• An increase in FEV1 and/or FVC ≥12% of control and ≥ 200 mL constitutes a positive bronchodilator response.
• In the absence of a significant increase in FEV1 and/or FVC, an improvement in lung function parameters within the tidal breathing range, such as increased partial flows and decrease of lung hyperinflation, may explain a decrease in dyspnoea. The lack of a bronchodilator response in the laboratory does not preclude a clinical response to bronchodilator therapy

Upper Airway Obstruction



FIXED OBSTRUCTION	VARIABLE EXTRATHORACIC	VARIABLE INTRATHORACIC
Post intubation tracheal stenosis Goitre Bronchial stenosis Endotracheal neoplasms	Vocal cord paralysis Vocal cord constriction Decreased pharyngeal cross sectional area Airway burns	Tracheomalacia Polychondritis Tumors of lower trachea or main bronchus
Maximum airflow is limited in both inspiration and expiration to a similar extent	Maximum airflow is restricted in inspiration because -ve pressure narrows the trachea. Restriction I > E	Maximum airflow is restricted in expiration because of increased intrathoracic pressure compressing the airway.

THANK YOU